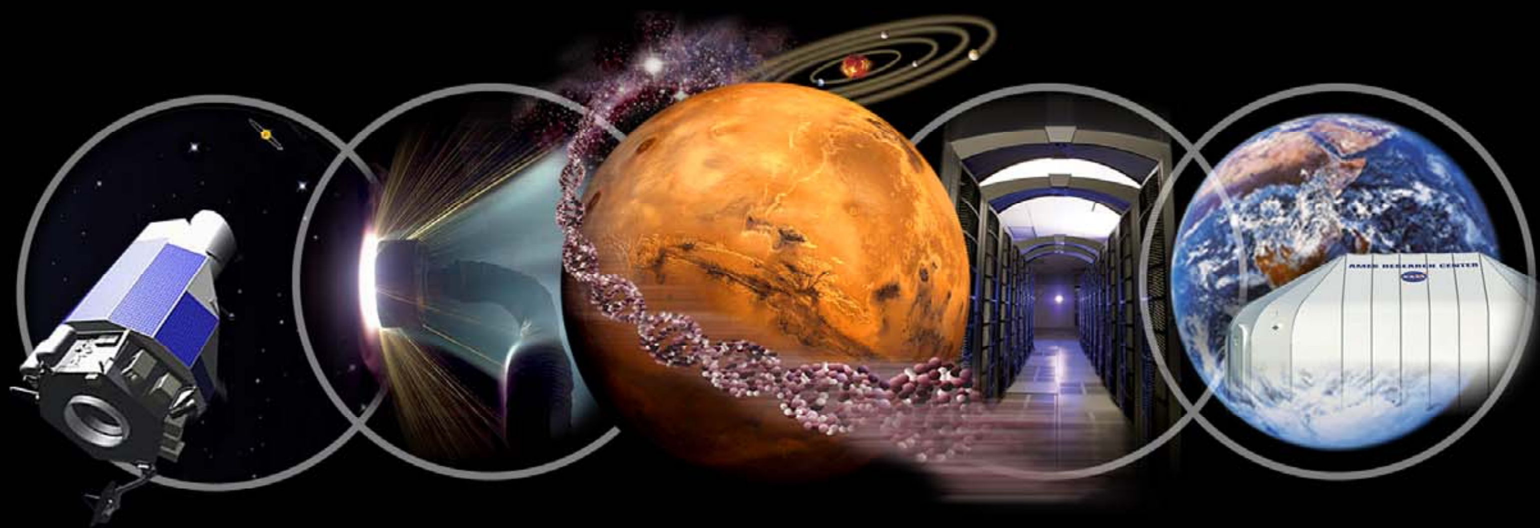
Discovery ➲ Innovation ➲ Solutions



Human Support Technologies

Michael Flynn
PI ALS Project

Ames Exploration System Technology Partnerships Forum
July 22-23, 2004

Visibility ➲ Excellence ➲ Impact

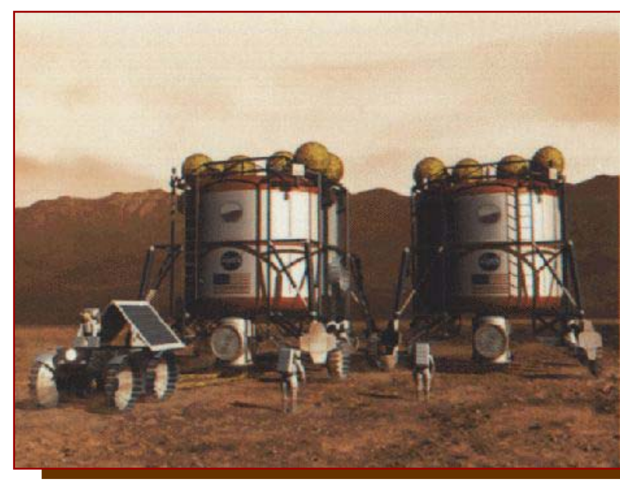
Ames Research Center

Contents

Advanced Life Support Project

Goal:

Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.



Objective:

Develop knowledge and technologies to make life-support systems self-sufficient and improve human performance in space.

Role of NASA Ames in Advanced Life Support

- **R&TD focus:**
  - **- Regenerative Air, Water & Solid Waste Processing Technologies**
  - **- Systems Integration, Modeling, and Analysis**
  - **- Fundamental Research through Hardware Development (TRL 1-6)**

- **Develop prototype subsystems at appropriate TRL levels for integration into testbed development and evaluation.**

Recent NASA-ARC success stories

Systems Modeling, Analysis and Controls

- ARC expertise in Systems Engineering tools development & trade studies for life support design.
- ARC development of dynamic mass flow models for closed systems.
- ARC Systems Engineering support for AIM project at JSC for high level integration of human mission systems.

Water Recovery System

- ARC development of a TRL 5-6 single step water recovery system (VPCAR) with no consumables or maintenance requirements for 3 years.
- *Equivalent Systems Mass metric is five times better than ISS system.*
- Acceptance testing at ARC in FY04, followed by human-rated testing at JSC.
- Key candidate subsystem technology for integrated testing in AIM at JSC.

Air Revitalization System

- ARC development of TRL 5 solid state technology (TSAC) which solves the main technical challenge in closing the air loop in spacecraft.
- *Saves ~2000 lbs/yr in resupply consumables over existing ISS system.*
- Significant advantages over mechanical compressor alternative.
- Applications to *In Situ Resource Utilization* for planetary missions.

Waste Processing/Resource Recovery (ARC is Agency Lead)

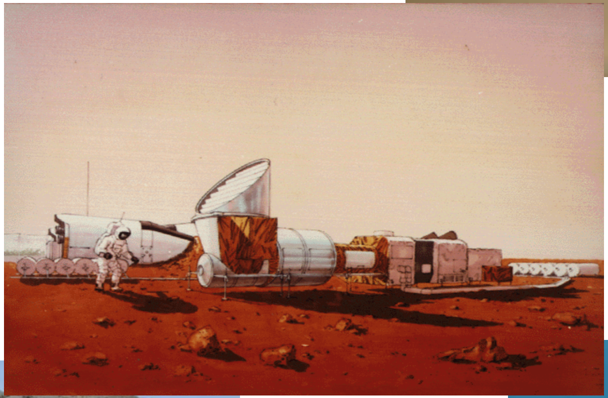
- ARC development of a waste oxidation/incineration system successfully utilized in ALS Phase III 90-day human-rated closed test at JSC.
- ARC NRA on utilization of carbon nanotubes for conversion of trace contaminants into usable products (NOx to N_2 and O_2).
- *Potentially superior Trace Contaminant Control System.*
- ARC development of technologies to mitigate wet trash/waste on ISS.

ISRU Capabilities

These capabilities support the following H&RT program elements:

ASTP/Software, Intelligent Systems & Modeling

TMP/Lunar and Planetary Surface Operations



- ***Rover Platforms***
- ***Visualization Software***
- ***Rapid Prototyping***
- ***Autonomous operation, robotic vision, navigation and mobility technologies***
- ***Gas separation, purification, storage, and compression***
- ***High Efficiency Pulse Tube Coolers***
- ***Liquefiers***

ISRU Facilities

- ***Intelligent Robotics Laboratory***
  - *K9 rover*
  - *Visualization tools*
- ***Adsorption Laboratory***
  - *Gas separation, purification, storage, and compression processes of gases*
- ***Mars Simulation Chamber***
  - *200 liter working volume*
- ***Marscape Test Facility***
  - *Outdoor 3/4 acre high-fidelity planetary science test yard*
- ***Mars Surface Wind Tunnel***
  - *0.01 atm Ambient Pressure Environment*
- ***Cryogenics Laboratory***
  - *High Efficiency Pulse Tube Coolers*
  - *Liquefiers*

Cryogenic Fluid Management Capabilities

These capabilities support the H&RT program elements:

ASTP/Power, Propulsion and Chemical Systems
TMP/High Energy Space Systems Technology
TMP/Lunar and Planetary Surface Operations Technology

- ***Zero Boil Off Cryogen Storage***
- ***High Efficiency Pulse Tube Coolers***
- ***Advanced Regenerator Development***
- ***Liquefiers for ISRU***
- ***Distributed Active Cooling Systems***
- ***Cryogenic Thermal Contact Conductance***
- ***Flow Metering***
- ***Insulation***
- ***Thermal Analysis***

Cryogenic Fluid Management Facilities

- ***Pulse Tube Development Facility***
  - *High Efficiency Pulse Tube Coolers*
  - *Liquefiers*
- ***Distributed Active Cooling Test Facility***
  - *Active Joule-Thomson Coolers*
- ***Cryogenic Insulation Test Facility***
  - *Thermal conductivity in vacuum or in the presence of atmospheric analogue gases*
  - *Moisture condensation (launch pad environment simulation)*
- ***Thermal Contact Test Facility***
  - *Thermal conductance of pressed contacts at cryogenic temperatures (1.6 K to 77 K)*

Human Factors Research and Technology

Human performance issues pervade NASA missions

Aerospace Systems depend on people for safety, reliability, efficiency, maintenance, operations...

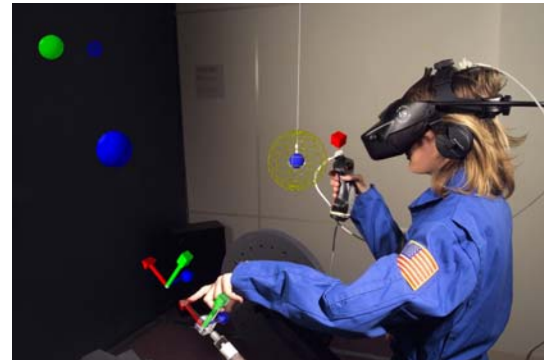
- **Human ingenuity makes systems resilient through adaptive, creative, flexible, opportunistic problem-solving.**
- **People recognize novel problems.**

People are accountable . . .

. . . even for highly autonomous systems

- **Automation creates supervisory monitoring and control problems**
- **Understanding human requirements is critical to mission concept definition**

Core Technical Competencies



1. Aerospace Human Factors
   - Fatigue, Workload
   - Automation, Training
   - Air-Ground collaboration
   - Crew decision-making
   - Risk perception
   - Cockpit Displays

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2. Computational Modeling for

esign tools

3. Multi-modal Integration
   - Advanced displays
   - Virtual reality systems

4. IT Decision Support Tools
   - System monitoring & evaluation
   - Data mining & visualization

Human-Performance Modeling

Computer simulation of human cognitive, motor, perceptual processing

Enables

- Mission requirements for human exploration
- Formal task analysis and "what-if" simulation
- Rapid processing of experimental human performance data
- Simulated Human-in-the-loop engineering design
- Intelligent tutoring and decision support systems able to diagnose and anticipate information requirements of human operators
- Intelligent agents for large-scale simulation

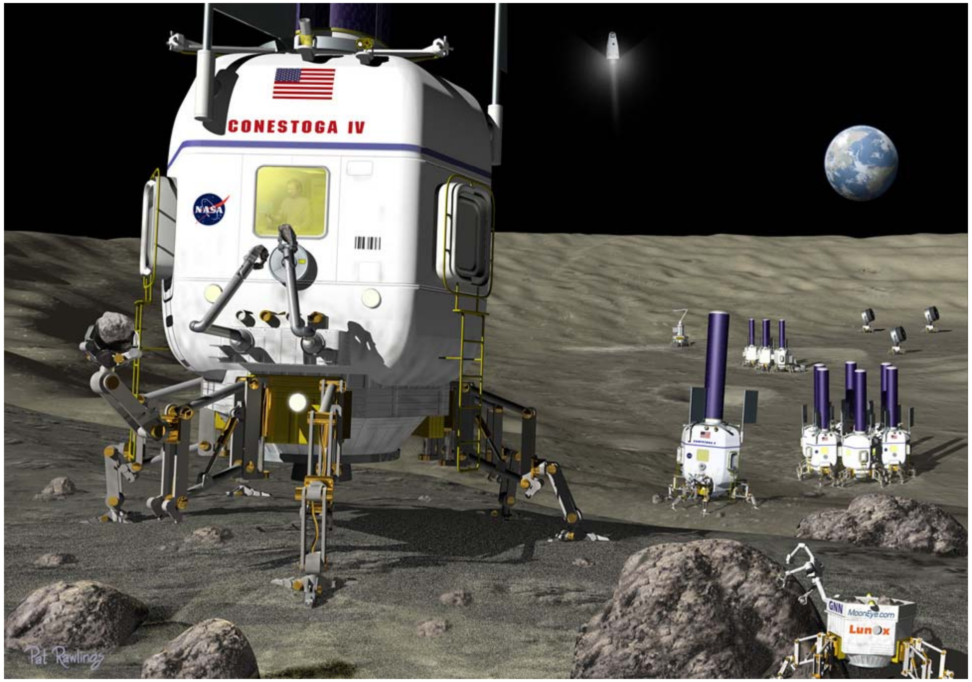
Multiple Human Performance Models used at Ames:

MIDAS, air-MIDAS, APEX, CATS, ACT-R, among others

Habitat Research

Habot Mobile Lunar Base Concept

- **Habot: Habitat Robot**
- Combine human and robotic exploration capabilities.
- Suitable for mass production & cost reduction through economies of scale.
- A self-mobile habitat that lands autonomously at a landing zone on the Moon.
- Habots cluster together to form a base-habitat complex.
- Human Crew arrives after verification of the Habot Base.
- ***Habot is Human-Rated ONLY on the surface of the Moon. It is not an orbital or Cislunar crew vehicle.***



Habot Mission Profile

100 Day Nominal Expedition

- **2 Lunar Day/Night Cycles**
- **= 56 Sols**
- **8 Sols Planned Margin**
- **36 Sols Reserve**
- **Between Crew Expeditions, Habots traverse to a new site.**
- **Each Habot is 5 to 10 mTons**

- **Launch on an Atlas 5 or similar vehicle.**
- **4 Crew Members**
- **10 Crew Expeditions**
- **560 Sols total planned surface duration**
- **1000 Sols total capability**
- **4000 Crew Sols capability**
- **Two or more Habot units have roving capability separate from the base.**

Composite Habitat Research

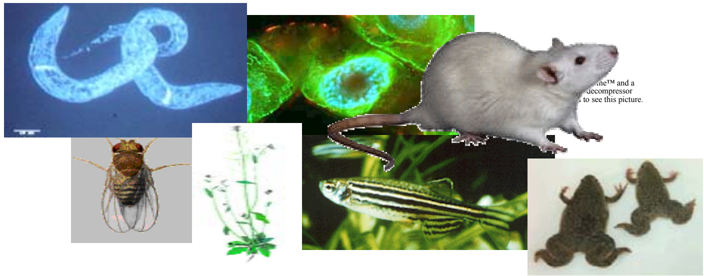
- Reduce weight, improve micrometeoroid protection, increase thermal stability and insulation, and improve radiation shielding by eliminating metallic emitters of secondary neutrons.

- It will confer benefits on both piloted and unpiloted spacecraft:

  Improved, lighter weight thermal insulation, heat rejection systems, and micrometeoroid shielding; and, systematic and comprehensive characterization of the new generations of lightweight composites, foams, and gels as aerospace materials and structures.

- The Composite Habitat Project will enhance NASA's ability to protect the health and safety of astronauts from a range of the most significant threats: explosive decompression, radiation exposure, outgassing, and micrometeoroid exposure.

Astrobionics



- *In-situ* Technologies and Products For NASA's Fundamental Biology, Space Biological Research, BioAstronautics, and AstroBiology Programs

- Emerging miniaturized and integrated earth-based science, engineering, and information technologies for accommodation on free-flyer, and manned space missions

- New technologies to support monitoring and diagnostic techniques for cell, tissue culture, and small organism research

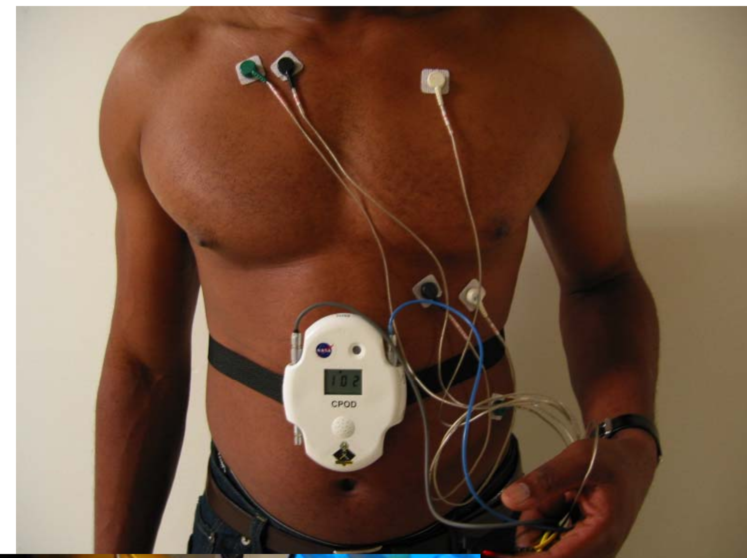
- New technologies to allow genomic, proteomic, metabolic and structural data to be collected and integrated with organ, physiological, and behavioral systems data during long-duration spaceflight

LifeGuard - Wireless Physiological Monitor

The LifeGuard system was developed for monitoring the health of astronauts during space flight.

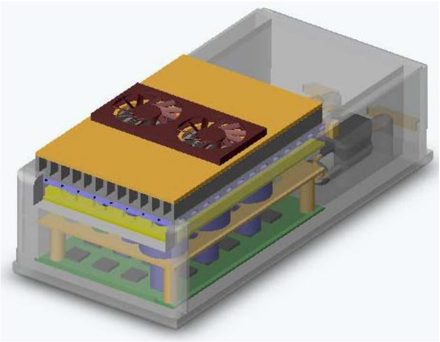
Measure; ECG (2channels), respiration, activity (3-axis acceleration), temperature (skin or ambient), heart rate, pulse oximetry (SpO2), and diastolic and systolic blood pressure.

The wearable device acquires and logs these physiological parameters up to 9 hours and can download or stream them in real time to a base station PC on demand.

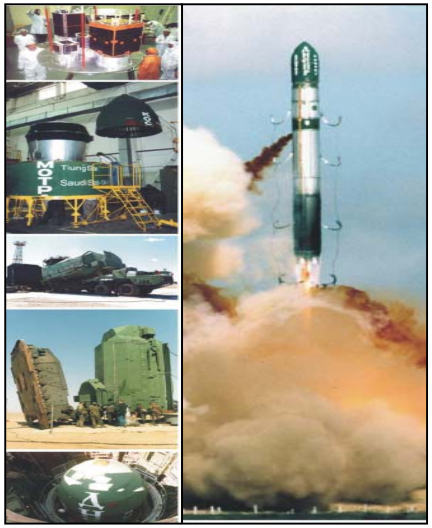


ISGEN: *In-Situ Genetics Experiments on Nanosatellites*

Fully automated, in-situ, miniaturized systems (1.5 - 15 kg) that provide life support for, then measure and telemeter genetic changes in, model micro-organisms: *C. elegans*, *Drosophila*, yeast, *E. coli*.



Flying many missions using this low-cost 2°-payload-compatible technology will lead to better understanding of the biological effects of the spaceflight environment, particularly radiation, enabling countermeasure development: a critical need for safe long-duration space missions.



Points of Contacts

•Advanced Life Support	Mark Kliss	650-604-6246
•In-Situ Resource Utilization	Louis Salerno	650-604-3189
•Cryogenic Fluid Management	Louis Salerno	650-604-3189
•Human Factors Research and Technology	Patricia Jones	650-604-1345
•Habitat Research	Mark Cohen	650-604-0068
•Astrobionics	John Hines	650-604-5538

Presenter **Michael Flynn** **650-604-1163**